U.S. DEPARTMENT OF AGRICULTURE.

THE SCIENTIFIC WORK

OF THE DEPARTMENT

IN ITS

RELATIONS TO PRACTICAL AGRICULTURE.

BY

EDWIN WILLITS,

ASSISTANT SECRETARY OF AGRICULTURE.

ADVANCE SHEETS FROM THE REPORT OF THE SECRETARY OF AGRICULTURE FOR 1890.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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SPECIAL REPORT OF THE ASSISTANT SECRETARY

SIR: In accordance with your request, I beg leave to submit the following review of the scientific work of the Department in its relations to practical agriculture, to form a part of the Annual Report of the Department.

Trusting that it may fully cover the object which you had in view, and that its publication may serve to emphasize in the minds of the readers the determined effort in every division of this Department under your administration to conduct all the work in a manner subservient to the best interests of practical agriculture, I have the honor to remain,

Very respectfully, yours,

EDWIN WILLITS,
Assistant Secretary.

HON. J. M. RUSK,
Secretary of Agriculture.

THE SCIENTIFIC WORK OF THE DEPARTMENT IN ITS RELATIONS TO PRACTICAL AGRICULTURE.

Agriculture to be permanently successful must be founded on, and conducted according to scientific principle. As all legislation not in accordance with fundamental economic laws will sooner or later fail in its beneficent purpose, so agriculture without an intelligent apprehension of its conditions and limitations, without a wise consideration of the laws to which it is subject, without a proper application of every means to enhance its productiveness, will ultimately fail to respond to expectations and will bring disaster to the farmer. Nature can not be cheated, and her implacable laws will surely find out their transgressors. There is a plague-stricken soil as well as a plague-stricken population. Sanitation and vegetation are not accidents: for both there are arts that promote and arts that prevent injury. Science is at the bottom of each.

Science is classified knowledge. This knowledge comes from experience and from investigation. It is as important to know what

has been done as to know what it is possible to do. Science arranges the facts of the former in line and finds a law; or it investigates, projects itself into the unknown, and discovers other laws or amplifies those already known. Men who heed these laws avoid mistakes, conserve their energies, and double production.

The practical farmer too often forgets or ignores what he owes to science. He perhaps is sometimes not aware of the obligation. How many farmers, for instance in the temperate zone, would be moved to build a monument to the man or men who invented hay as adapted to modern use? Yet in a large sense hay is a modern discovery, based upon long experiments made in the importation, cultivation, and improvement of grasses till then unknown to the agriculturist. As recently as the sixteenth century the average weight of the bullocks bought for the English navy was less than 400 pounds. For want of hay the sheep were mostly killed in November, and such as were left were, with the oxen, starved through the winter, so that improvement was impossible. The grass experiments, scientific and practical, of the Duke of Bedford and others, made the 2,000 pound bullock possible, by furnishing food for continuous unstinted growth, winter and summer, from birth to maturity. It was by no accident that the few useful grasses upon which are based the live stock and dairy interests in the magnificent proportions of the present time were brought from diverse countries and made subservient to the interests of mankind.

How long it took the world to learn that proper rotation of crops "rests the land" as effectually as fallowing, thereby saving one crop and sometimes two a year; to learn that the increase of live stock on the farm within and under certain conditions increases its fertility; to learn that artificial drainage warms and lightens cold and heavy soils, advancing the harvest by weeks and bringing the subsoil to the relief of the impoverished surface, by which as some one has said we find a new farm under the old one, or as Emerson so graphically says, "by drainage we have gone to the subsoil, and we have a Concord under Concord, a Middlesex under Middlesex, and a basement story of Massachusetts more valuable than the superstructure." These matters were all demonstrated by the application of scientific principles long before adoption by the world at large.

It is perhaps a waste of words to continue a further discussion of what agriculture owes to science. Illustrations multiply as the ever-widening field is traversed. Suffice it to say that to the introduction of scientific methods and processes is due in large measure the elevation of those who till the soil to their present high estate. Science carries intelligence with it wherever it goes, and its wains are freighted with the burdens of increased harvests. In line with this sentiment and in furtherance of the demand of the farmers of the United States, was founded

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As far back as 1822 a strong effort was made to transform the "Mall," some 200 acres, between the Capitol and Executive Mansion, then almost a barren waste, into an experiment farm, in which should be propagated for distribution new and rare seeds and plants. Nothing came of the agitation in that form, but in due time a division was established in the Patent Office to gather facts and disseminate information for the benefit of agriculture, and after a while to purchase new and rare seeds and plants in limited quantities for gratuitous distribution. The demand for better things grew till finally a separate and independent department was set up on 40 acres of the "Mall" which forty and more years before was sought for an experiment farm. With this transfer came enlarged powers and duties. In accord with enlightened progress, the means were given for original, scientific investigation. Several new divisions were created for that purpose, among which chemistry was chief. Since then, from time to time, other lines of inquiry have been added till there is hardly a topic of investigation relating to agriculture, suggested by modern thought, that is not in greater or less degree covered by the work of the Department. Its halls are instinct with science. The chiefs of the divisions and many of their subordinates are eminent in their special lines, and are recognized for their work and their ability the world over as the peers of any like body of investigators, seek where you may.

One of the gratifying features of this development in scientific research is that the practical character of the work has not one whit abated. Much more than one half of the money appropriated is used for the gathering of facts and statistics, for the purchase and distribution of seeds and plants, for the extirpation of contagious diseases of animals, for the introduction of and experiments with forage plants, for the inspection of meats and animals intended for export, and finally, for the dissemination of information. The most abstruse scientific inquiry is tempered by a practical impulse. The best scientific work has for its end the useful and the permanent good of agriculture. Here is exemplified what history again and again shows, that the best and highest scientific work has always been allied with the useful. Men need to be harnessed to facts, theories need to be in touch with realities to produce the best results; truths substantially verified in our experience. At the same time the publications issued by the Department constitute a mass of information the most extensive and varied among the nations of the earth. The annual report, of 400,000 copies, constitutes the largest single edition of any book published. In their practical character, in their scientific worth, and in the promptness of their issue, our publications are the admiration of all representatives of foreign

governments accredited to the Department to study its workings and efficiency.

So much it is thought is due to make it clear that in this development the cardinal purpose and duty of the Department is not lost sight of. It remains now to consider in detail the

SCIENTIFIC WORK OF THE DEPARTMENT.

This work may be properly divided into three classes: (1) The experimental; (2) the remedial; and (3) general science.

As a matter of fact this classification is not made by divisions, but largely characterizes the work of all the divisions. The classification is generic, not divisional.

I.—THE EXPERIMENTAL.

This may be subdivided for more clear definition into (1) the empirical, and (2) the economic.

The empirical.—This term empirical is used for the want of a better, though not strictly accurate. By the term is meant that class of experiments which are not popularly considered scientific, though in fact based upon a scientific principle. This work is more fully carried on by the Seed Division, the Horticultural Division, the Pomological Division, and the Botanical Division.

The distribution of improved and valuable seeds and plants is sound policy, because based upon natural law. In a wide sense nature has made her own distribution which all experiments must recognize, and it is the study of the laws of this distribution that constitutes the scientific element of the empirical work, and which renders our definition not strictly accurate. For instance, it was practically a useless waste of funds to distribute cotton seed to the State of Michigan, which was done for a while under the ironclad appropriation that each Congressman should receive his quota of all seeds—an anomaly subsequently rectified. Climatic and other considerations (really scientific) should have their weight in the purchase and distribution. But, within comparatively certain lines, there is a wide field for improvement in quality and product, by the judicious introduction of new varieties and the transfer of valuable ones from one locality and condition to another.

While nature in the broad sense has placed her varieties of vegetable life in the regions to which they are best, and sometimes where they are exclusively adapted, there are some very marked exceptions. For instance, the potato, corn (maize), and tobacco were indigenous only on this continent. Their transfer to Europe has been an untold benefit to its teeming population. The transfer to England, in the seventeenth and eighteenth century, of some of

the grasses indigenous in Virginia and Maryland, rendered it in large measure possible to make the hay in abundance, which has been noted near the beginning of this article, and which was the prime cause of the modern development of the cattle industry. The planting of the Eucalyptus tree, indigenous in Australia, has been a boon to treeless Southern California. We need not to be reminded that nearly all our cereals as well as our domestic animals are of European or Eastern origin. These illustrations cover broad lines, but they are sufficient to establish the fact that the securing of new seeds and plants for distribution is a paying investment properly conducted. On the other hand, it is equally as susceptible of demonstration that the distribution of valuable seeds and plants, not new, but well known, from one locality to another, is promotive of a higher and better production. Taken from a locality where they succeed at their best estate, they carry with them to their new home some of the impulse and vitality they took on where they were grown. This is nature's secret at the bottom of the benefits in "change of seed."

Recognizing these facts (based, as has been noted, on scientific reasons), Congress for nearly fifty years has appropriated funds for the purchase and distribution of new and valuable seeds and plants, and has committed the duty of carrying on the work to the Department of Agriculture. While it is conceded that many mistakes have been made and some notable failures have occurred, the fact remains indisputable that great benefits have been conferred upon the agriculture of the United States by the distribution. We can, out of many, give only a few illustrations. Take one from the Seed Division, that of the wheats sent out. Many kinds have been distributed. The most of them appear in the list of those now cultivated, but the number disseminated is of little importance compared with the prominence of some of them in the wheat growing of the present day. The variety which has the widest distribution is the "Fultz," a red winter wheat, which originated in Pennsylvania, and was distributed in 1871 and subsequent years. The area now occupied by it is four times as much as that devoted to any other wheat, and probably occupies one third of the area seeded in winter wheat, producing at least one fourth of the wheat harvest of the country. The next in extent is the "Mediterranean." This was imported by the Department twenty-five years ago and for several subsequent seasons from Marseilles, France, and grown on the islands of the Mediterranean Sea. The next was the "Fife." It is almost as prominent among spring wheats in the proportion of its cultivation as is the Fultz in the domain of winter wheats. It is the great wheat of the Northwest, introduced by the Department. The next and fourth in importance is the "Clawson," so well known in Michigan. Many more might be mentioned, taking a lower rank,

but which are leading varieties in many localities. The four named yield nearly or quite one half of our usual crop. Last year the Department distributed seven home varieties and four new imported ones. The home varieties consisted of three new improved ones and four of more than local celebrity, to be transferred to the localities in which they were not grown. Of the four imported two were of Black Sea and Italian parentage, for our Southern States, and two of English and French parentage; all raised in and thoroughly acclimatized to France. It is hoped that out of the four we may find at least one substantial acquisition. They all may prove failures. That is the reason why the experiment is called empirical, having as it does a large element of chance in it, though careful study was made of the strain, of the varieties, and the conditions of production.

So much for the Seed Division, though illustrations too numerous for this article suggest themselves. Let us take one or two from the work of the Horticultural Division. This deals largely, of course, with plants. It first introduced the Russian apple, which has such rare success in the West and North. It introduced the Japan persimmon, which has become so largely cultivated in Florida and California. The celebrated Washington navel orange of California was propagated from a tree growing in the hothouse of this Department. Those who have seen this wonderful orange grow will concur in the statement one repeatedly hears in California, that the introduction of this one variety was worth more to the country than the total cost of the Department of Agriculture. The original plant came from Bahia, Brazil. It took three years and two failures before success was attained, and then only in rearing a single tree, from which has come such a progeny. We can not stop to enumerate the catalogue of fruits and plants and fibers introduced, of the pineapple, olives and figs, dates, and citron. We will stop, however, long enough to speak of the citrons and figs recently imported by the Pomological Division, and of the date palms from Egypt, just distributed in California and Arizona, and upon which great expectations hang.

The Botanical Division is specially charged with the experiments with the grasses and other forage plants. During the existence of the Department the Seed Division gave much attention to the distribution of grass seeds, but it is not till within the last two years that the thorough and exhaustive experiment has been assigned to a division which shall make it a specialty. It is believed that the era which was inaugurated by the English experimenters, heretofore noted, can be repeated; that they did not exhaust the subject; that new grasses and forage plants can be found that will successfully enlarge the list. Another reason for entering upon the work is that the results of the English experiment accrue only to a comparatively

small portion of the United States. The conditions south of Virginia and Kentucky and west of the Missouri River are so different that the staple forage plants will not thrive in economic production. The South needs a new line of grasses as much as did England in the sixteenth century, and for substantially the same reason. The Great West, which is developing so rapidly, presents altogether another problem. All the grasses known to us in the North have been practically discarded there and others are supplanting them. The list is at present small, even under irrigation, and the hope is that it may be largely increased; while without irrigation there is as yet no known grass that will succeed under cultivation. Perhaps two thirds and more of that vast territory is not susceptible of irrigation. A considerable portion of this area is covered with native grasses of limited production that close and continuous pasturage destroys, leaving nothing in its place.

It is believed that from those native grasses, from those in Siberia, in India, and in South America, some varieties may be found that shall "stick" and thrive permanently, thereby quadrupling at least the production. It will doubtless take many years to accomplish this. It took England fifty years to develop her grass industry. Long before the expiration of half that time the advancing tide of population will utilize the results of these experiments, if successful, without in any sensible degree affecting the value of the products of the older and more thickly populated States. It is wise statesmanship to anticipate the wants of the future, and to determine how far it is practicable to make homes for the teeming millions to come. The Department of Agriculture is for the whole country, and should canvass the wants of all. The South, if these experiments prove a success, will find in them the means of restoring her sterile acres, and of preventing further depletion of her soil, and at the same time of developing an industry that shall make her more self-sustaining. The West may gradually force back the lines of the desert, and with grass to temper and forest trees to resist, may hope to modify the blizzards.

The economic.—This is the second branch of the experimental work. This characteristic may be found in all, but in a less degree than in the Chemical Division. The most marked feature of this division in this line is its work on the sugar question. This experiment and investigation is one of long standing. A large amount of work was done to determine whether there was sufficient saccharine matter in cornstalks to produce sugar with a profit. It was finally decided that there is not. Then, or in a measure concurrent with the corn experiments, began a long line of tests on sorghum; first, to determine the variety, the richest in saccharine qualities; second, to find the period of maturity productive of the largest yield, and at what stage of its growth the sugar would crystallize most readily,

and with least loss in molasses. The cane upon which these tests were made was planted, cultivated, and gathered under the supervision of the division. Both objects were satisfactorily determined, and for a time it looked as though the general production of sugar from sorghum would prove a success, but the price of raw sugar in the market took a large decline, so great that sugar from sorghum could not be economically produced, resulting in the collapse of the new industry, as well as that of the manufacture of glucose, a bastard sugar with which the genuine was adulterated. The experiments continued, however, taking the form of improving cane by careful scientific cultivation and propagation, so that the yield of sugar might be increased, and in determining what localities, if any, were adapted to its economic production. Considerable success has attended the work. The quality of the cane has been sensibly improved, and the regions of highest production pretty well defined; but at this date the promise for a general sorghum-sugar industry does not equal the high hopes of its most sanguine promoters, though it promises to be a success in a restricted locality. The experiment, however, has proved a most valuable one, even where it has failed, worth all and more than it cost, in that it has been demonstrated that sugar in unlimited quantities at a price but little above the cost of foreign sugars can be manufactured, so that in case of national emergency or scarcity abroad our country may be amply supplied with home products.

If the maxim "In time of peace prepare for war," is a good one in a military sense, it is no less so in an economic. A great deal of scientific work has been done in the analysis of the cane, in the study of all the processes of extracting the juice and its manufacture, in the improvement of the machinery and apparatus, in the elimination of waste by new methods and new processes, so that a full knowledge of the conditions and the possibilities of the industry has been obtained. These experiments have not been limited to sorghum cane, but have covered that of the sugar cane of Louisiana. With the latter the improvement is so marked that it is worthy of special note. The industry in Louisiana has been of so long standing that comparisons can be made. It has been proven that by modern processes developed with the coöperation of the division, and in many respects under its direct instruction, the yield of sugar from a given average ton of cane can be raised from 120 to 200 pounds, the difference of 80 pounds being lost in the operation conducted according to the old methods. When the new processes shall be applied by all the cane-sugar producers, an increase of product in the area of present cultivation would be effected to the value of more than $10,000,000 annually. These results from both the sorghum and the cane experiments amply justify the work and the expenditure. These experiments still continue, and in addition, under direction of Congress,

he cultivation of the sugar beet, and the manufacture of sugar therefrom, have been taken up. A large amount of the best seed from Europe has been obtained and distributed in the localities supposed to be best adapted to their growth, and analyses of the beets from a wide region of country are being made. At this writing the most flattering hopes are excited from the showing made. The previous work done with sorghum and sugar cane makes the transition to the beet sugar inquiry an easy one, and its solution will be more rapid, intelligent, and satisfactory.

II.—THE REMEDIAL.

Vegetable and animal life are subject to similar conditions. A tree and an animal live essentially on the same elements. They both grow to maturity, and in due time die and decay. Both have their enemies and their diseases. There are diseased cattle and diseased vines. No one speaks of a diseased granite block. It is this life and its conditions, therefore, that has its enemies and its diseases. Anything that saps or stops nutrition is an enemy to life, and may be the cause of disease. Growth stopped, decay begins, and death ensues. Kill the enemies, stay the disease, and life continues to maturity and production. Whatever kills the enemy is a remedy, whatever stays the disease is a cure. Neither adds a particle to the inherent life. Both simply remove obstructions and life goes on. The means and methods of killing the enemies and curing diseases are *remedial*, and a large part of the work of the Department is the study of these remedies. The Division of Entomology is charged with the killing of the animal enemies that attack plant and animal life; the Division of Vegetable Pathology, with remedies for the diseases of plants; the Bureau of Animal Industry, the diseases of animals. We will discuss the work of the last two first.

Manifestly the most logical way is first to find the cause of the disease, then the work of finding a remedy is simplified; the finding of the cause in very many cases suggests the remedy. It is true that experiment often finds a remedy, but with great waste of time and energy if the cause is unknown. What is the cause of plant disease? What is "pear blight?" What is "peach yellow," or "apple scab," or "black rot" in the vine? What is that "vine disease" which goes through a vineyard as a "flame of fire?" What is "rust" in wheat? What is "potato rot?" What is "mildew?" Again, what is the cause of diseases in animals? What is "hog cholera," or "swine plague," or "pleuro-pneumonia," or "Texas fever," or "tuberculosis," or "glanders," or "horse distemper?"

Now, modern science has gone far toward demonstrating that the ultimate cause of all these diseases and many not named is an infinitesimal "germ" or "spore." This germ or spore has a mysterious life of its own that attacks the life of the plant or animal.

It attaches itself to the plant, and as a fungus sucks out its vitality. It enters the sap and destroys its nutritious qualities. It enters the blood, and curdles it as it were by its marvelous power of reproduction, till the "issues of life" are spent.

There is, however, a dispute, notably relating to plant diseases, as to whether these germs are the real cause of the disease, whether they are not in fact an effect. Worms, say one side, eat the dead body, not the live; mold takes hold of decaying not living wood. These spores attack only the dead or dying. The disease antedates the attack. Vultures will follow all day long the wounded deer to pounce upon him perhaps before his last expiring breath. So do these minute spores follow the decaying vitality of the seemingly vigorous plant, which is, in truth, moribund. In other words, that this fungus never troubles, or rather thrives on an absolutely healthy vine, but that the vine is in process of decay, though it may not seem so to the eye.

On the other hand, it is as emphatically claimed that it does attack healthy plants; that in the same orchard or vineyard, in the same row, where all grow in the same soil and are in the same condition of apparent health, growth, and vitality, one will be attacked and the other left; that the disease can be produced at will in healthy plants by inoculating the virus, that is the spore, into the sap; which facts would seem to settle the controversy in their favor. Whether it does or not, there can be no question that these spores either are the cause of death or hasten it, so that if they are killed before they have got in their work, the life is in one view saved, in the other prolonged. In either case the remedy is fruitful. The experiments of the Division of Vegetable Pathology fully establish this fact.

This diversity of opinion does not exist to the same extent, relative to the germ or spore existing in animal diseases. It is true, nevertheless, that it is claimed that many of the maladies are caused by the lack of vitality in the subject, by which it is unable to resist the attacks of the germs already in the system; that a healthy body has the ability to keep them in subjection, but any derangement, sometimes a simple cold and the hitherto inert forces take new life, and attack some vital part. It is manifest, however, that this theory will not account for diseases of a contagious type where an epidemic prevails, which travels over lines as well defined as a blizzard, striking down indiscriminately the strong and the weak, the apparently healthy as well as the unhealthy. There is, however, an unsolved mystery in the ways of these unseen messengers of death; one is taken and another is left, even under like exposure and apparently like conditions. If it be proved as claimed, that the causes of these diseases is a living germ, substantial progress has been made. They have form and substance and life, and it is a relief from the terror inspired by the conception that the cause is something in-

tangible as a spirit, impalpable as a ghost, but withering as a blast from the infernal regions. There is hope in the knowledge that these spores are living organisms, for it is almost axiomatic that every living thing can be killed. It may be by some poison, mineral or vegetable, by some substance that destroys the tissue in which it lives, by some parasite harmless to the animal but deadly to the germ, by the frosts of winter, by fire, fumigation and purification, whereby the nests in which it is bred, are wholly destroyed. It is believed that, as the next step, now that the cause is known, science will in time in each case find the remedy that shall kill the germ without killing the animal. It is a matter of some discouragement that up to date we have not been able to exterminate pleuropneumonia except in the destruction of the animal infected, but public attention has been sharply arrested on this point, and some of the ablest men of the world are investigating the problem. In the two divisions under consideration, experts are studying in all their forms and phases these germs or spores that prey upon animal and vegetable life. In the laboratory, in the field, with microscopes, with germ culture, with fungicides, with vaccination of other or similar, but less injurious germs, and in every way that science can suggest, or experiment can blaze the way, remedies are being sought, and in time, as before said, will be found in some form or other, as by Jenner for smallpox, Pasteur for hydrophobia, and Koch for tuberculosis.

The work of these two divisions, however, is not limited to this strictly scientific investigation. In the Division of Vegetable Pathology some of the experiments with fungicides have brought substantial results. A striking example bearing on this point is shown in the method of dealing with black rot of the grape. Before this disease was investigated by the Department, nearly every grape grower had a theory as to the cause of it, but the question of a remedy was entirely beyond the imagination of the most sanguine. By scientific investigations which covered months, it was shown that the disease was due to a microscopic fungus, and that the fungus passed through several stages. The character and life history of the fungus was determined, and this knowledge suggested the remedy which, when applied intelligently, can save the crop. Many farmers and fruit growers who have followed the instructions of the Department this year have saved from 80 to 90 per cent. of their crop, while there was almost a total failure in the portions of the vineyards untreated. Reports of this season's work justify the statement that in this one line more has been saved by the comparatively few who followed instructions than the total expenditure of the division in all lines. The division has had under investigation a large line of plant diseases, chief among which are "peach yellows," "pear blight," "apple and pear scab," "pear and cherry leaf blight," the "California

vine disease," "cotton anthracnose," "anthracnose of the hollyhock," a bacterial disease of the oat which is destroying millions of bushels, "rots" of the sweet and Irish potatoes, "mildew" and "anthracnose of the grape." In some the causes are still unknown or obscure. Others are perceptibly yielding to treatment, and there are high hopes of essential success in the near future.

The Bureau of Animal Industry was specially charged in 1886 with the eradication of pleuropneumonia among cattle, which at that time was so widespread and so terribly destructive. With a large force, mainly of veterinary experts, it attacked the disease, and has essentially stamped it out. To form some idea of the work done (and it was essentially scientific in its character), we need only to note the fact that from August 1, 1886, to November 30, 1888, there were inspected by the agents of the Bureau 50,838 herds, containing in all 300,737 cattle; there were found 1,428 infected herds, which contained 5,715 infected animals, and there were made 49,073 post-mortem examinations. Whenever a herd was found infected, or had an infected animal in it, it was at once quarantined, the infected animal slaughtered, and in fact large numbers of animals exposed to the contagion were likewise slaughtered and paid for by the Department. This work enlisted in its service the highest attainable skill in the country; for large interests were at stake, large sums of money expended, and a terrible evil was to be extirpated. That success has been attained is due in a large measure to the scientific work of the Department. In but one or two localities are there now any appearances or suspicions of the disease, and strict quarantine is still being made of all suspected animals. This is necessary for the reason that the germs of the disease may still exist in an undeveloped state, which on some propitious occasion will show itself and begin its devastating work. It is said that notwithstanding large expenditures of money in foreign countries, whence came the disease, nowhere has it been entirely eradicated; so, constant vigilance is required, not only to watch the least symptoms of revival of it here, but to prevent the importation of infected animals.

Entomology.—A large portion of our injurious insects are of foreign origin. We are the asylum of every downtrodden race of men, good, bad, and indifferent, and they bring with them from every clime the diseases and the insects incident to their countries. The result is that we are in number and variety the most pest-ridden country of the world. The Hessians are reputed as bringing with them the Hessian Fly, and it is not discrediting the Hessian soldier to say that the Hessian Fly has done far more harm to the country than did the soldier. George Washington could take him prisoner, but a generation could not capture the fly. The work, therefore, of the Division of Entomology is the most varied of any connected with the Department. When we take into account the fact that there are

already listed nearly or quite three hundred thousand varieties of insects, only a small portion, it is true, injurious to agriculture, but a large portion likely at any time to become so by some change of temperature, some change or increase in the humidity of the climate, or some want of its natural source of sustenance, which may precipitate them in countless hordes upon growing fields, the importance of the science of entomology will be so obvious as to lift it into public consideration. A universally effective insect powder would command as ready sale as a well advertised patent medicine. Insects are the scourge of every farmer and fruit grower, and the life-long plague of every thrifty housewife. The work of this division has been so constant in studying their life history and characteristics, and the means of checking their ravages, that it could hardly have failed, if it would, in accomplishing great good for agriculture. The information given as to remedies has been so ample, and the instructions as to methods of application have been so full, that it is needless to specify the particular instances of special benefit. The sum and substance of the instructions is to kill the insect and yet not kill the plant or animal or substance it infects. The experiments in insecticides and their application by spraying machines have been invaluable. These experiments have not been haphazard, but have been guided by scientific discrimination. One illustration will suffice. The persistent efforts of this division to discover a remedy for the ravages of the scale insect among the orange groves of California—ravages which in a short time from their beginning threatened to destroy this most promising branch of agriculture—have been crowned with success. It was due to the efforts of this division that a skilled entomologist was sent to Australia, where he discovered a parasite to the pest, though Australian scientists had denied its existence, and having discovered it brought home a supply for propagation in California. California fruit growers have asserted that the investigations and experiments have saved their oranges.

III.—GENERAL SCIENTIFIC WORK.

The Chemical Division has been conducting an important and fruitful series of tests to determine the extent and character of adulteration of the food, drugs, and liquors offered for sale in American markets, and has made analyses of grasses and cereals, of soils and waters, as occasion has required and the means at hand have afforded opportunity.

The Forestry Division has devoted itself to the study of the life histories of trees, and the distribution and extent of forests, the prevalence and characteristics of varieties of forest growths, and the modifications arising from differences in climate and soil, and to a series of mechanical tests and laboratory examinations to determine more satisfactorily the qualities of our many timbers, grown under

different conditions, so that the wood worker and user may more intelligently make his choice of timbers from different localities and for different purposes.

In the Division of Ornithology the whole question of distribution of plants and animals, the food habits of birds and mammals, and the relation of these to agriculture, horticulture, and forestry has been primarily considered, and much valuable fieldwork has already been performed. The results to be obtained can be hardly less important than those already referred to as accomplished and hoped for in connection with the distribution of cereal, vegetable, fruit, and grass seeds by the Department for economic purposes. An accurate survey showing, as regards altitude and latitude, the habitat of any given indigenous species will serve to the scientist as a starting point for the consideration of the multitudinous questions brought to his attention with respect to the adaptability of any given locality to the growth of any given economic plant. In this study the Botanical, the Pomological, and the Forestry Division are contributors.

The Division of Pomology is creating for itself a wide field of usefulness in connection with the study of varieties of fruits and the effect of change from a given climate and soil to another, and the Botanical Division is engaged in a similar work in respect to plants and grasses. The National Herbarium, under the control of the Botanical Division, is winning recognition and approval from the botanists of the world, both by reason of the extent of its collections and the excellence of its system of classification.

The Entomological Division has for its scientific function the collection and classification of insects and the study of the conditions which promote or retard their increase and of their capabilities of usefulness or mischief. The reputation of the division among scientific men was world-wide years ago, and it has suffered nothing in standing or reputation of late years.

The study of the habits of the silkworm is now pursued in the Silk Section, and forms the chief scientific function of the section. The study promises to result in the distribution of the best varieties of the worm.

The Microscopical Division is rendering valuable public service by applying the microscope to the study of food adulteration and the character of textile fibers.

Important scientific work has been performed by a special agent of the Department in relation to the adaptability of some of the most economic fiber plants to growth in different sections of the country, and practical results of the study have been embodied in publications setting forth suggestions as to the best methods of cultivation, decortication, and separation from woods and gums.

Statistical Division and Office of Experiment Stations.—If it be

true, as Comte says, that the test of a science is its power of prediction, the highest order of economic science finds full play in the Statistical Division and of agricultural science in the Office of Experiment Stations. It is said that in no one thing did Gladstone in his prime show his wonderful abilities more than in forecasting the production and revenues of England. He reasoned from the known to the unknown. The Statistical Division more than any other considers all the forces that enter into the great and varied agricultural productions in our vast domain, so that intelligence shall decide what to plant, where to plant, and when to plant. The Office of Experiment Stations is charged with the scientific work of comparing, editing, and publishing the results of the experiments made by the experiment stations, and to indicate, from time to time, such lines of inquiry as shall seem most important. It goes without saying that this work calls for the highest scientific qualities. To take a comprehensive view of the work of nearly four hundred independent workers in the scientific field, to properly digest the same for publication, and to suggest lines of work and lines of experiment requires the ablest talent the country can produce. The relations of this Department with the agricultural colleges and experiment stations are and should be very intimate. They were both born of the same impulse. The act to establish a Department of Agriculture (before that it was, as heretofore stated, a division of the Patent Office) was approved May 15, 1862. The act establishing the agricultural colleges was approved July 2, 1862. The act establishing agricultural experiment stations was approved March 2, 1887. The bill to make this Department one of the Executive Departments of the Government was pending at that date before Congress, and had passed the House of Representatives, and finally became an act, approved February 9, 1889. The historian will recognize the significance of this coördinate legislation. It means a movement all along the lines of science applied to agriculture. These colleges and experiment stations are nurseries of applied science.

This article will have failed of its object if it does not satisfy the most skeptical that this Department in applying its scientific work to the wants of the great industry it represents, is fully abreast with the marching columns of this new movement.